SURVEY OF MANUFACTURING CAPABILITIES FOR SMALL-PIXEL UV IMAGES FOR THE LUNAR ULTRAVIOLET TRANSIT EXPERIMENT (LUTE)

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FINAL REPORT

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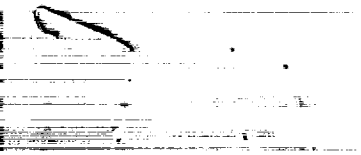

OBJECTIVE 1: Completion of strawman LUTE CCD of approximately 25 X 7 mm format, for feasibility evaluation.

(1) The completed design is shown in Fig. (1). This design utilizes the desired 5-micron pixel size for LUTE, in a 5124 X 1416 pixel format, designed as a TDI drift-scan imager with a single readout port. Some details of the output amplifier structures are shown in Fig. (2).

(2) An AutoCAD or GDSII digital file of this design is available in PC format if desired, and will be maintained at this location for at least one more year.

OBJECTIVE 2: Evaluation of potential domestic suppliers for small-pixel imagers in this large format.

(1) The completed strawman CCD design was taken to the SPIE Conference on Astronomical Imaging (Kona HI, Mar 94) and shown to but other researchers in the CCD field and to representatives of most of the domestic fabrication firms for this technology. From these informal meetings and contacts, it was established that only three US fabrication facilities could at present attempt to produce large-format CCDs with pixels as small as 5 microns: Kodak, Loral, and Orbit Semiconductor. None had ever tried to do so, however. The other vendors examined, EG&G Reticon, Sarnoff Labs, and Scientific Imaging Technology (SITe) did not possess photolithography capabilities that would allow a large-format, small pixel imager to be realized. Based on these important meetings, visits to the three candidate firms were organized.

(2) Site visit to Kodak, Rochester NY. I presented the detailed strawman design to the chief designer on their CCD imager development team, Dr. T. Lee, and others. The following conclusions and implications for producing an imager similar to the strawman were established as a result:

(a) Kodak's stepper imager for precision lithography has only a 20mm field. Thus to print an imager as big as the LUTE strawman, two passes with separate masks must be made for each layer, driving up both NRE and recurring costs. Kodak was unwilling to discuss very specific numbers as to what an initial foundry effort to do a LUTE-like imager would cost, but said that it might exceed $200k.

(b) They have no 3-phase capability, 2-phase only. This means that two separate flavors of CCD must be produced for a final LUTE focal plane, since the serial registers cannot be made bidirectional.

(c) They have extensive experience in CCD imagers with pixels approaching 6 microns, allowing them to estimate the charge capacity of a 5-micron imager fairly precisely for their process. The Kodak process can yield up to 6000 electrons per sq. micron of phase area, or perhaps as much as 40k electrons full well.

(3) Site visit to Orbit Semiconductor, Sunnyvale CA. Details of the strawman design were discussed with P. Suni, head of CCD processing. Orbit does not at present have stepper imager for the required lithographic precision for a full-format LUTE CCD, but expects to have this capability in the near future. However, they have no experience with small-pixel imagers at all, meaning that processing for minimum channel stop widths must be developed first in order to optimize full-well capacity. Costs for an initial experimental run of 20 wafers might slightly exceed their usual level for CCD runs by perhaps 20-30%, putting it at about $140k-150k.

(4) Site visit to Loral-Fairchild, Newport Beach CA. Hosted by R. Bredthauer, chief of CCD processing. Facility was in the process of closing, but large CCD operations are to be shifted to a brand new state-of-the-art facility in Manassas VA (Loral Federal Systems). This facility may have the capability of doing whole-wafer lithography of the required precision and in any event could do it using a stepper projector. The team has some experience in producing small-pixel imagers and the technology for very narrow channel stops in order to maximize full-well capacity. Projected costs for an initial experimental batch of 10 wafers (125 mm rather than the usual 100 mm) were the lowest of all potential vendors, with NRE of about $25k and production at approximately $46k.

CONCLUSIONS AND RECOMMENDATIONS:

If the LUTE project goes forward in its presently conceived configuration, with a goal of 5-micron resolution, then a development effort at Loral Federal Systems seems the most cost-effective way of evaluating feasibility of this difficult technological step. It is clear that such an imager can be produced, and work. What is unclear is what the charge capacity will be, and whether it would be enough to satisfy mission requirements.

Should such an effort at Loral fail to achieve satisfactory results, the best alternative would probably be Kodak, However, costs for such an effort would most probably be greatly increased, at least several-fold.

The need for the 5-micron pixel has been driven largely by the very short focal length of the proposed LUTE telescope, and some of the science that researchers have proposed to do with it. Since large pixels (6 microns and above) are much more readily producible and require little or no development effort from the major vendors, it would be wise to consider such alternatives to the strawman requirement. This is especially true if the severe constraints on telescope design are substantially modified in the future by new alternatives in launch vehicle and payload size/weight, allowing for a longer focal length and therefore larger pixels in the focal plane.

Fig.(1): Completed strawman design for an operational CCD drift-scan imager for LUTE.

Fig.(2): Blowup of output amplifier (upper left corner).